SCIENCE

NTU scientists a step closer to using velvet worm's slime as bioplastic

They have uncovered the exact constitution of proteins in the sticky slime squirted to nab prey

Gena Soh

Velvet worms are the carnivorous cowboys of the invertebrate world, using slime "ammunition" to catch prey.

This sticky substance, touted as a possible plastic replacement, is squirted out of two "muskets" from the sides of the worm's mouth.

The slime is famed for its ability to harden to trap prey in a string-like web as strong as nylon, and also to dissolve completely when exposed to water.

The exact composition of the slime has so far eluded researchers, but a team of scientists from Nanyang Technological University (NTU) have just uncovered the exact constitution of proteins in the slime.

This brings the slime from the endangered worm a step closer towards having commercial viability as a biodegradable plastic or adhesive.

The supervisor of the study, Professor Ali Miserez, from NTU's School of Materials Science and Engineering (MSE) and School of Biological Sciences, said that although it was known "a long time ago that the slime was mostly made of proteins, no one knew the complete sequence of amino acids of the proteins".

Amino acids are the basic building blocks of proteins. There are 20 different amino acids in total, all with different chemical compositions and capable of different types of chemical reactions.

Furthermore, Prof Miserez said, it was understood that the hardening mechanism behind the slime was caused by the sudden assembly of many different slime proteins into a larger complex, known as a biopolymer, under certain conditions.

Biopolymers can be thought of as elongated molecules that can be made of proteins or other types of large molecules such as cellulose, the main building block of wood.

Listing common biopolymers like silk and spider webs, which have attracted much public interest, Prof Miserez said: "But these (slime proteins) are special in that they will form bonds with each other to make the slime solid but not strong enough such that we cannot dissolve it afterwards."

He added that charting the exact sequence of amino acids in these polypeptides would therefore allow scientists to study how exactly these proteins interact with one another to give rise to the slime's unique qualities.

It is estimated that around five more years of work will be required before an artificial version of the slime can be manufactured on a larger scale. Further proof-of-concept experiments will then have to be done on the artificial slime before it is ready for commercial use.

As part of the sequencing research, one of the first authors of the study, NTU scientist Bhargy Sharma from MSE, discovered that a short section of one protein contributed to the slime forming tiny droplets, like oil in water.

This section, known as the N-Terminus, or the extremity of a protein, was instrumental in enabling the proteins to form the droplets surrounded by water.

These droplets are like "islands" of concentrated amounts of proteins that make the slime very viscous but not solid, so that it can be stored by the animal in its body before ejection.

Prof Miserez said this discovery would not have been possible if scientists did not have the complete amino acid sequence.

Funded by the Singapore Energy Centre (SgEC), the study supervised by Prof Miserez's team and conducted primarily by Dr Bhargy and Dr Yang Lu, who has since left NTU, was published last month in Advanced Science – one of the top multidisciplinary scientific journals in the world.

SgEC is a consortium founded by NTU, the National University of Singapore, and founding members such as ExxonMobil.

While the scientists recognise their achievement, they acknowledge that this research is still far from being incorporated into a consumable product.

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Despite this, Prof Miserez stresses that fundamental research is essential.

"Many research studies actually begin with very basic and fundamental aims, with scientists not being able to predict whether their research will eventually be used in life-changing creations," he said.

One life-changing invention that Prof Miserez's team recently developed was a novel method of delivering drugs into human cells using large biological molecules, by first encasing them in a protein-based micro droplet.

However, what is less well-known is that this discovery was directly inspired by a protein from the beak of squids, said Prof Miserez.

The squid beak is a very hard material, but unlike vertebrates' teeth (like human teeth), it is not calcified but a combination of proteins and chitin, another type of biopolymer, as discovered by a team of scientists led by Prof Miserez in 2008.

Citing the example of the squid beak protein, Prof Miserez said: "I had no idea that I would use this discovery eventually to deliver vaccines or anti-cancer drugs."

He added: "Research is an ongoing process that never stops: For every question answered, there will be two more questions that arise unanswered."

Returning to the velvet worm's slime proteins, he said: "Maybe with these proteins, we will have something similar one day or another application we may have never thought of in the first place."

"It is not impossible," he added.

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Suspected new species found in S'pore

The velvet worm is far from being a worm.

Existing in its own biological classification known as Onychophora, fossils of these velvety creatures have been dated as far back as around 500 million years ago.

A team of Nanyang Technological University (NTU) scientists suspect that during their research into the velvet worm's slime, they have stumbled onto a new species of this prehistoric worm in the forests of Singapore.

Dr Bhargy Sharma, a research fellow at NTU's School of Materials Science and Engineering and one of the lead authors of the research paper, said: "When we began the study three years ago, we heard that there were velvet worms that were native to Singapore and so decided to use them for our study."

The study she refers to is on the proteins in the velvet worm's slime.

It was supervised by Professor Ali Miserez and conducted primarily by Dr Bhargy and Dr Yang Lu, who has since left NTU. It was published in the journal Advanced Science.

Dr Bhargy added: "While we knew these worms were native to Singapore, we thought they had migrated from Thailand a long time ago, where the closest known tropical species of velvet worm is known to originate."

However, in the course of their research and through correspondence with other velvet worm scientists in Germany and Canada, it came to the team's attention that the worms were physically different from the velvet worms of other species.

Dr Lu added that genetic differences were also found between the Singapore velvet worms and other Asian ones.

Dr Lu said: "The phylogenetic similarity of marker genes to all known species in the National Centre for Biotechnology Information database is less than 80 per cent, even to the species found in Thailand."

Sequences with less than 95 per cent similarity were already considered as different species, although this can be arbitrarily defined, Dr Lu said.

The team has since sent specimens to scientists in Germany and Canada for analysis.

Should the Singapore velvet worm be confirmed as a new species, the team hopes to integrate Singapura into the species' name.

Dr Bhargy said: "If this worm is confirmed to be a species specific to Singapore, this would open up so many interesting questions for me. Like when did the worms genetically diverge from other Asian worms? And how?"

She added: "Since they can't migrate by sea, a new species could suggest that these worms were in Singapore maybe more than 500 million years ago."

Dr Lu said: "There were also theories that they may move with soil or even wood material transported between countries or islands."

Ultimately, Dr Lu added, more scientific research has to be done to verify this suspicion.

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Left: A velvet worm being "tickled" to get it to eject its slime at NTU's Centre for Biomimetic Sensor Science. The sticky substance is touted as a possible biodegradable replacement for plastic.

Top: Fibre generated from the slime of the velvet worm. While it has been known for a long time that the slime is mostly made of proteins, it was only recently that NTU scientists were able to sequence the amino acids of the proteins.

Above: A network of crude slime fibres from the velvet worm. The slime is known for its ability to harden to trap prey in a web as strong as nylon, and also to dissolve completely when exposed to water.

Right: The mouth and oral papillae of the worm, from which the slime is squirted out.

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